AMENDMENT UNDER 37 CFR § 1.111
Serial No. 09/577,814

Entered
BY
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AMENDMENTS TO THE SPECIFICATION

Please amend page 1, lines 4 through 11, of the specification as follows:

This application is related to co-pending and co-assigned United States Patent Application No. ~~__________~~ 09/539,707 filed on ~~__________,~~ March 31, 2000, entitled METHOD AND SYSTEM FOR ESTABLISHING CONTENT-FLEXIBLE CONNECTIONS IN A COMMUNICATIONS NETWORK, and United States Patent Application No. ~~__________~~ 09/522,593 filed on April 19, 2000, entitled HYPER-CONCATENATION ACROSS MULTIPLE PARALLEL CHANNELS, which are both hereby incorporated herein by reference.

Please amend page 1, line 21 through page 2, line 27, of the specification as follows:

Co-pending and co-assigned United States Patent Application No. 09/539,707 filed on ~~______~~ March 31, 2000, and entitled METHOD AND SYSTEM FOR ESTABLISHING CONTENT-FLEXIBLE CONNECTIONS IN A COMMUNICATIONS NETWORK teaches a technique for establishing an open connection (OP-N), mapped across a communications network. The OP-N connection is "concatenatable", in that an end user can transport arbitrarily concatenated signal traffic through the OP-N connection. In principle, virtually any combination of concatenated and non-concatenated signals may be used, up to the bandwidth capacity of the OP-N connection. The traffic mixture (i.e., the mix of concatenated and non-concatenated traffic) within the OP-N connection can be selected by the end user to satisfy their requirements, and may be changed by the end user as those requirements change, without requiring re-configuration of the OP-N connection. For example, with an OP-6O connection (i.e. N=60, so that the connection has a bandwidth capacity equivalent to an Optical Carrier OC-60 signal) an end user could arbitrarily change from a traffic mix of five STS-12c signals to one OC-48c and 12 (unconcatenated) STS-1 signals or two STS-24 and two STM-4 signals as required. Other traffic combinations are also possible, all at the discretion of the end user, and without intervention from a network service provider.

A limitation of the OP-N connection is that, although it can incorporated multiple channels, in general, the bandwidth of the highest capacity channel (e.g. a wavelength in a Wave Division Multiplexed – WDM, or Dense Wave Division Multiplexed - DWDM network) limits connection size. Thus, if the highest capacity channel of the OP-60 connection operates at a bit-rate of 2.488GHz, then an OC-48c is the largest connection that can be supported by the ~~OC~~<u>OP</u>-60.

Please amend page 5, lines 1 through 16, of the specification as follows:

Co-pending and co-assigned United States Patent Application No. <u>09/522,593</u>, filed April 19, 2000, and entitled HYPER-CONCATENATION ACROSS MULTIPLE PARALLEL CHANNELS, teaches a method for aligning two or more data streams being conveyed within respective parallel channels. In this system, data signals (which may comprise an arbitrary mixture of concatenated and non-concatenated signal traffic) are inverse-multiplexed and transported hop-by-hop through a hyper-concatenated connection distributed across multiple parallel hyper-concatenated channels. At a downstream end of each hop (including at the end node), the hyper-concatenated data streams are aligned by a signal processor having a plurality of parallel interconnected channel processors. At the end node of the hyper-concatenated connection, the original data signals are recovered from the hyper-concatenated data streams.

Please amend page 7, lines 12 through 15, of the specification as follows:

Accordingly, a method and apparatus for transporting arbitrarily concatenated signal traffic through a hyper-concatenated connection across independent point<u>er</u> processors is highly desirable.

Please amend page 14, lines 8 through 26, of the specification as follows:

The invention further relates to network nodes adapted to serve as start nodes or end nodes for hyper-concatenated connections in accordance with the invention. The start nodes have input ports adapted to receive concatenated input signals, and signal processors adapted to inverse multiplex the concatenated input signal across the channels of the hyper-concatenated connection. The start node also has output ports ~~are~~ adapted to launch

the inverse-multiplexed input signal across the network space as hyper-concatenated data streams within respective ones of the channels. The network nodes adapted to function as end nodes have input ports adapted to receive hyper-concatenated data streams from adjacent optical channels. The received signals are written to respective read buffers in adjacent pointer processor state machines that include adjustable read pointers that permit frames received from the respective hyper-concatenated data streams to be read out in alignment to reconstruct the concatenated signal.

Please amend page 16, lines 17 through page 18 line 2, of the specification as follows:

Fig. 2 is a schematic diagram illustrating an exemplary set-up of the hyper-concatenated connection 24 mapped between the source and end nodes 18a and ~~10b~~18b. In the illustrated embodiment, the hyper-concatenated connection 24 is an OP-192 connection, thus having a bandwidth equivalent to N = 192 STS-1 signals. Within this connection, signal concatenation is not provisioned, so that an arbitrary concatenation scheme (up to the bandwidth capacity of the hyper-concatenated connection) can be defined by an end user. As shown in Fig. 2, the hyper-concatenated connection 24 may be constructed using a layered model. For example, the network service provider may elect to set up high bandwidth OP-N core connections between cross-connects 12a, 12b within the core of the network. In the illustrated example, these high bandwidth core connections include an OP-768 core connection 26 set up between the first and second cross-connects 12a and 12b. The hyper-concatenated connection 24 is set up, for example, by a network service provider in response to a request from an end user for an end-to-end open connection having a bandwidth of N = 192. Setting up this end-to-end open connection requires that the network service provider establish feeder OP-192 connections 28 and 30 between the start node 18a and the first cross-connect 12a, and between the second cross-connect 12b and the end node ~~10b~~18b. These feeder OP-192 connections 28,30 are then linked by a virtual OP-192 connection 32 which is set up by allocating a portion of the bandwidth of the OP-768 core connection 26 previously established between the two cross-connects 12a and 12b.

Throughout the length of the end-to-end hyper-concatenated connection 24, a predetermined number of channels are utilized. High bandwidth data traffic originating at

the communications device 16a is inverse-multiplexed across the hyper-concatenated channels of the hyper-concatenated connection 24, at the start node 18a, and launched as hyper-concatenated data streams through the hyper-concatenated connection 24. Each channel of the hyper-concatenated connection 24 carries a respective hyper-concatenated data stream. Two or more hyper-concatenated channels may be multiplexed within a single waveguide (e.g. optical fiber) or distributed over two or more waveguides. At the end node ~~10b~~18b, the hyper-concatenated data streams are recombined to recover the original high bandwidth concatenated signal. This inverse-multiplexing and recovery process is preferably transparent to service users.

Please amend page 21, line 28 through page 22 line 29, of the specification as follows:

In the embodiment shown in Fig. 3 the start node 18a has one input port 31 and one output port 34 for the sake of simplicity in illustration. However, it will be appreciated that the start node 18a is normally provisioned with a plurality of ports, of which one or more may be used for the hyper-concatenated connection 24. It will also be appreciated that the ports of the start node 18a may be configured to handle bi-directional data traffic. However, in order to simplify the present description, and aid understanding of the invention, the embodiment shown in Fig. 3 is equipped with unidirectional ports, one of which (input port ~~28~~31) is configured to handle inbound signal traffic, and the other (output port 34) is configured to handle outbound signal traffic.

As shown in Fig. 3, the signal processor 32 receives a serial concatenated data stream containing an arbitrary mix of low bandwidth signals and high bandwidth concatenated signals. The serial data stream may be received through a single input port ~~28~~31, as shown, or may be distributed across two or more ports. The signal processor 32 is designed to process the serial data stream to split the respective signals across the multiple channels of the hyper-concatenated connection 24, in accordance with the channel assignments associated with the hyper-concatenated connection 24. The switch fabric 38 is configured to route data streams on a per-channel basis to the output port 24 for transmission through the hyper-concatenated connection 24. Per-channel routing of data streams through the switch fabric 38, and subsequent multiplexing of channels onto

a downstream fiber, are known in the art, and therefore will not be described in further detail.

Please amend page 23, lines 11 through 22, of the specification as follows:

In the example shown in Fig. 3, hyper-concatenated connection 24 is configured with Q=4 adjacent channels, which are nominally identified as channels CH(1) – CH(4). The high bandwidth signal 42 originating from the end user's communications device 16a is a SONET STS-Kc signal composed of 192 concatenated STS-1 frames (thus K=192), which are nominally identified as F(1)-F(192). This high bandwidth signal 42 is split by the signal processor 32 into four derived SONET signals 44a – ~~44e~~44d, each of which includes 48 of the STS-1 frames. Thus, in the example of Fig. 3, each derived signal is a derived STS-Mc signal, in which M=48.

Please amend page 29, line 23 through page 30 line 6, of the specification as follows:

As mentioned above, each derived STS-M signal 44a-d is indistinguishable from any standard SONET/SDH signal. Accordingly, each of the derived STS-M signals 44 can be routed across the network ~~2~~10 between the start node 18a and end node 18b using conventional SONET/SDH routing equipment and methods. Each derived STS-M signal 44a-d can be routed independently, and thus may follow different paths through the network 10 and may be subject to independent pointer processing at intermediate nodes 12a,b, 14b. However, if the split described above were not performed, these signals could not be transported independently as there would be no pointer information, only concatenation indicators at the split locations.

Please amend page 33, line 29 through page 35 line 14, of the specification as follows:

In order to align the frames arriving in the independent data streams of the hyper-concatenated connection, one of the channels (in the illustrated example, channel CH(2)) is selected as a reference channel, and the remaining channels of the hyper-concatenated connection 24 are designated as slave channels. The reference channel

may be arbitrarily selected, though a channel having a propagation delay in about a middle of the range of propagation delays is preferred. Within the reference pointer processor state machine 48b, the read operation is controlled such that the read pointer 56b is located at approximately the mid point of the alignment buffer 52b. The respective read pointers 56a,56c and 56d in each of the slave pointer processor state machines 48a,48c and 48d are then adjusted to compensate for differences in propagation delay across the network ~~20~~10. In addition, the read clocks (not shown) in each of the slave pointer processor state machines 48a,48c and 48d are synchronized with that of the reference pointer processor state machine 48b so that each successive payload byte is read substantially simultaneously from each of the FIFOs. Finally, a valid payload pointer PP indicating a location of a first payload byte within each frame, as well as any required stuff indications, are passed from the reference pointer processor state machine 48b to each of the slave pointer processor state machines 48a, 48c and 48d. Thus it will be seen that the high bandwidth signal originating at the communications device 16a and split into multiple derived signals 44 in the start node 18a, is reconstructed in the end node 18b so that it is interpreted at the communications device 16b the same as if the signal were passed directly from communications device 16a to communications device 16b.

In the foregoing description, the start node 18a and end node 18b are located at the network edge, and serve to mediate traffic flows between end-user communications devices 16a,b and the network 10. However it should be noted that the present invention is not limited to this embodiment. One, or both, of the signal processor 32 and signal recombination circuit 46 may, for example, be located in respective nodes 12a-c, 14a-b within the network 10. In particular, the methods and apparatus of the present invention can be used to enable high bandwidth traffic flows within the network core, for example, through the OP-768 connection ~~20~~26, (see Fig. 2) if the connection is routed through one or more legacy nodes or through independent pointer processing state machines.